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SOME OBSERVATIONS AND EXPERIMENTS ON THE NATURAL AND ARTIFICIAL INCUBATION OF THE EGG OF THE COMMON FOWL.

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Through a series of experiments on the developing chick, it was found that frequently the variations in development were so great that the value of the experiment was materially decreased. An attempt was therefore made to obtain more data regarding the following factors; position of eggs, turning of eggs, cooling of eggs, ventilation of eggs, moisture of eggs.

Before detailing the observations and experiments it should be emphasized that the eggs used were selected with much care. They were largely from the variety of fowls known as "Plymouth Rock." Especial care was taken to eliminate the effects of disease, inbreeding, poor food, etc. No eggs were taken from flocks in which there was not at least one cock for every ten hens. All mottled, rough shelled and ill-shaped eggs were discarded. Uniformity in size was next secured. The eggs were then tested by transmitted sunlight and those in the same stages of development selected.

POSITION OF EGGS.

That the position of the egg during incubation has an influence on the development of the chick was shown by Dareste ('91, p. 171). It is also a well known fact among poultry raisers that the position of the egg has a profound influence upon the growth of the chick. All seem to agree that if the small end of the egg is up, the head of the chick develops in this end, and as a result, many chicks will either be deformed or fail to free themselves from the shell at the time of hatching. With these points in mind, a series of observations was made with a view of determining just what position the eggs occupy during natural incubation.

Natural Position. — Two nests containing an aggregate of twenty-seven eggs were selected which were typical of the extreme conditions. One of these was exceedingly flat, being on the ground. The other, being in a box of straw, had a very concave bottom, so that the eggs were crowded closely together; those at the periphery always rested on a sloping side.

In each of these nests, the eggs were marked so that any change of position was readily noted. A diagram of the nest was made each day, showing the position of each egg and the angle of inclination of its long axis. The sketches were made at the time the hen was feeding. If she did not leave the nest, as sometimes occurred, she was gently removed until the sketch could be made.

The angles were assigned according to the following method: an egg whose long axis formed an angle of less than 10° with the horizontal plane was marked 0°. If the long axis formed an angle of more than 10° and less than 22½° it was recorded as 15°. If the angle were more than 22½° and less than 67½° it was recorded as 45 degrees. While those whose angles were more than 67½° were recorded as 90 degrees. It was found to be impossible to register the exact angle without the expenditure of much more time than the problem merited.

In the nest with the flat bottom there was an average of less than 10 per cent. of the eggs, in which the angle of inclination exceeded 15°. From this nest of twelve eggs eleven hatched, giving a percentage of 91.7.

In the second nest which was extremely concave an average of 30 per cent. of the eggs showed an inclination of 45° or more. From this nest containing fifteen eggs, thirteen hatched, giving a percentage of 86.6. Three other nests on the ground were compared with those in straw, but in these the percentage of chicks hatched was about the same. These observations led to the conclusion that the oblique position of the egg is a factor of little or no importance in natural incubation.

It should be added that in natural incubation, one very rarely finds eggs so placed that the smaller end is uppermost. This is probably the result of two mechanical factors. Those eggs at the margin, when beneath the hen, assume an oblique position

owing to the fact that this is the position in which least resistance is met; a second factor is that of specific gravity. The air space naturally tends to become uppermost and as this increases in size, the center of gravity becomes lower and lower, and the number of eggs assuming oblique positions increases as incubation progresses. It must, however, be kept in mind that an egg under natural conditions, does not maintain a position such that its angle is constant, and it may be that this varying angle of inclination influences development.

Experiments. — In order to ascertain what influence the position of the egg during artificial incubation has upon development, the following experiments were made:

In one tray of twelve-row capacity, the eggs were arranged in the following manner: Six rows were filled with eggs placed in such a position that their long axes were in a horizontal plane. Each row contained eight eggs, there being thus forty-eight eggs lying flat. In the remaining six rows the eggs were placed in such a position that their long axes coincided with an angle of 45°. Each of these rows contained ten eggs, giving sixty eggs placed obliquely. That the value of the results might not be lessened through the introduction of bad lots of eggs, they were controlled by taking equal numbers of these eggs from three different flocks of fowls and evenly distributing them throughout the tray.

On the fifth day thirteen infertile eggs were removed from those placed obliquely, leaving forty-seven living embryos. These eggs were again examined on the sixteenth day, and five dead embryos were found, leaving forty-two chicks alive at this time. Forty chicks hatched; the remaining two died after having pipped; the percentage of hatched chicks from the fertile eggs being 85.0.

From the forty-eight eggs lying flat, ten infertile eggs were removed on the fifth day, leaving thirty-eight live embryos. The sixteenth day, nine dead embryos were removed, leaving twenty-nine living chicks; of these eighteen hatched; three died after having pipped, and the remainder died in the shell. The percentage of chicks hatched from the fertile eggs was 47.3.

It is, of course, perfectly obvious that in this experiment, the

results indicated that eggs placed obliquely hatched a far higher percentage than those placed flat.

In a second experiment, the eggs were arranged in precisely the same manner, but in another incubator provided with a special ventilating apparatus. The fifth day, the eggs placed obliquely were tested and eight discarded. On the ninth day, three dead embryos were removed, and on the sixteenth day, four more were dead, leaving a total of fifty-three living eggs; forty-seven chicks hatched. Of the remaining six, four were dead in the shell, and two pipped. Thus there were hatched from those eggs placed obliquely, 88.7 per cent. of the fertile eggs.

From the forty-eight eggs placed flat, seven were found infertile on the fifth day. On the ninth day, six dead embryos were removed. On the sixteenth day, but one dead embryo was found. Thirty four chicks hatched. There was hatched about 83 per cent. of the fertile eggs.

The results of the foregoing observations and experiments taken together, lead to the deduction that when the supply of fresh air (oxygen) is inadequate, the oblique position of the egg, thereby bringing the embryo in closer contact with the air chamber, is decidedly advantageous. When there is an abundant supply of fresh air, there is but little to be gained through placing the eggs obliquely.

Turning of Eggs.

How many times the hen turns her eggs during the time of natural incubation is a question often asked, but as yet unanswered. Reaumer ('49, p. 166) states that they are turned daily and Dareste ('91, p. 161) that they are often turned twice daily. Believing this to be a point well worthy of investigation, a series of observations was made with the hope of obtaining some information as to the influence this factor plays in development.

Experiments have previously been made with a view of ascertaining what influence turning the egg has upon development. Dareste ('91, p. 165) placed sixteen eggs under the same conditions of artificial incubation. Eight were unmoved, while the remaining eight were turned twice each day. In the first set absorption of the yolk did not occur in any case; the embryos

died during the second or third week. Of the eight which were turned six developed normally; a seventh was opened on the twenty-second day, showing normal conditions; while in the eighth the chick died on the twentieth day, the adhesions between the allantois and the yolk having prevented the absorption of the latter.

Natural Turning. — In order to obtain satisfactory data, it was necessary to arrange nests in such a manner that the position of each egg could be sketched at frequent intervals without disturbing the hen. Three nests with felt sides and concave glass bottoms were constructed, and placed in such positions that the eggs could be viewed and sketched from below. The eggs were numbered in four places about equally distant from each other and midway between the two ends of the egg. Each figure bore an alphabetical index. The numbers on egg 1 would run thus: 1*a*, 1*b*, 1*c*, 1*d*, so that any degree of turning might be readily observed. Five sketches or plats of each nest were made each day during the incubating period, and at the following hours: 6 A. M., 9 A. M., 12 M., 3 P. M., 6 P. M.

The observations show that the eggs are turned partially or completely much more frequently than has been supposed, at least five times during any given day. It should also be stated that on a number of days sketches were made at more frequent intervals, and in nearly every case the eggs had been partially or completely rotated. The observations made were confined to the twelve hours between 6 A. M. and 6 P. M. A number of scattered observations lead to the belief that the eggs are also turned during the night, but just how frequently is yet to be determined.

The hen turns the eggs in two ways. If a sitting hen be watched as she returns from feeding to sitting, it will be seen that she moves her body rapidly from side to side. Whether the object be to turn the eggs is uncertain. Probably the first object is to bring the surface of the body in the closest possible contact with the growing embryos. Accidentally or purposely, she also turns the eggs. This is not only true of the hen returning from feeding, but also when on the nest, for she is frequently observed moving about and settling down with the same charac-

teristic lateral movements. Sometimes there are so many eggs in the nest or they are so widely scattered that the hen fails to properly cover them. When such conditions occur, the hen invariably uses her beak to bring the outlying eggs in contact with her body. Not only does she frequently thus turn the eggs, but also she very often reaches beneath her body and turns the eggs lying near the center of the nest. Why she does this is a question which awaits an answer.

Experiments. — Seventy-five eggs were selected from three lots of fowls, arranged in three groups and so placed that the eggs from one lot of fowls alternated with those from another lot. Those eggs of group I. were left unmoved; those of group II. were turned at 6 A. M., and 6 P. M.; those of group III. were turned at 6 A. M., 9 A. M., 12 M., 3 P. M. and 6 P. M.

From group I., five infertile eggs were removed on the fifth day, together with eight dead embryos, six of which had grown fast to the shell membrane. The eggs were again examined on the twelfth day and five more dead embryos were removed. These were examined and four were found to have the allantois grown fast to the yolk; but three chicks hatched from the entire twenty-five. The remaining four were dead in the shell. The number hatched was 15 per cent. of the fertile eggs.

In group II. there were three infertile eggs removed on the fifth day, and one dead embryo which had adhered to the shell membrane. On the twelfth day four dead embryos were removed, one had the allantois adhering to the yoke. In the others the cause of death could only be surmised. From the remainder, ten chicks were hatched; the others died in the shell, giving a hatch of 45.4 per cent. of the fertile eggs.

In group III. six infertile eggs were found on the fifth day and no dead embryos. On the twelfth day one dead embryo was found. Eleven chicks hatched; two died after having pipped, while the remaining five were dead in the shell; the number of hatched chicks being 58 per cent. of the fertile eggs. The experiments indicate that frequent turnings (at least five) give best results.

It is necessary to point out, however, that a very low percentage of chicks hatched even in group III. This is to be attributed

directly to a lack of sufficient oxygen, the incubator in which the experiments were made being poorly ventilated, owing to the fact that the ventilating system had been modified in order to compare its results with those provided with special ventilation. A second incubator provided with a special ventilating apparatus, hatched 83 per cent. and 88.6 per cent. of two lots of eggs taken from the same fowls.

Dareste concluded from his experiments that during the first week of artificial incubation, eggs which are unturned develop in essentially the same manner as those which are turned. The principal cause of death is due to the allantois growing fast to the yolk, causing the rupture of the vitelline membrane, thereby allowing the yolk to escape so that it cannot be taken into the body of the embryo. Dareste adds that when the eggs are turned it is probable that the position of the allantois is shifted, and this movement prevents its adhesion to the yolk. It should be remarked that during the early days of incubation it is also necessary to turn the eggs frequently; otherwise, the embryo grows fast to the shell membrane. This has not only been shown by the preceding experiments, but has been repeatedly observed in other eggs.

IV. Temperature of Eggs.

Repeated attempts have been made to ascertain the temperature of the egg during natural incubation, but as yet the results are far from satisfactory. This is due to the difficulty experienced in testing the temperature of different parts of the egg. The fact that the egg comes in contact with a heating surface above and a cooling surface below, leads to most perplexing complications. While the temperature of the hen is easily ascertained, it is not an easy matter to know the precise degree of heat applied to the surface of the egg. Moreover, it should be kept in mind that during incubation, not all the eggs are at all times in contact with the body of the hen. A layer of feathers intervenes to modify the temperature, this layer varying greatly in thickness in different parts of the body, and at different times during incubation. All these factors conspire to make an exceedingly difficult problem.

Natural Temperature of Hen. — In attempting to determine the daily temperature of the hen, special self-registering thermometers were fastened to blocks so cut that their upper surfaces were nearly egg-shaped. The lower surfaces of the blocks were broad and flat, so that they could not be easily overturned. One was placed in each of four nests and left for two or three hours, when the reading was made.

The following table shows the temperatures obtained by this method, during twenty days of incubation. In this as in subsequent tables, the Roman numerals indicate the serial numbers by which the hens were designated, while those above the columns indicate the day of incubation.

	1	2	3	4	5	6	7	8	9	10
I.	102.1	103.0	103.0	103.8	105.0	104.5	105.0	105.0	106.2	106.0
II.	103.0	104.0	103.5	104.5	104.5	104.0	105.0	105.5	104.5	104.6
III.	102.0	102.0	103.0	103.0	105.0	105.0	104.5	104.0	104.5	104.0
IV.	101.5	102.5	102.5	103.0	103.5	104.0	104.5	104.5	105.0	105.0
	11	12	13	14	15	16	17	18	19	20
I.	105.0	104.5	105.0	105.5	104.5	105.5	104.8	105.0	104.5	105.5
II.	104.6	104.5	104.6	104.2	105.0	104.8	105.0	105.0	105.0	104.0
III.	104.0	105.0	104.0	103.6	104.0	105.2	104.2	103.5	103.0	104.0
IV.	104.8	105.0	104.5	105.0	104.8	105.0	105.0	104.5	104.5	105.0

A second series of readings was made by gently removing the hen from the nest and placing the thermometer in the groin for five minutes. The results are of course, somewhat unsatisfactory, since the excitement of the fowls due to their being removed from the nest, results in a temperature somewhat higher than the normal.

	1	2	3	4	5	6	7	8	9	10
I.	103.0	104.0	103.5	104.6	105.5	105.0	106.0	106.0	105.5	106.0
II.	104.0	105.2	105.5	105.5	105.5	106.5	105.2	106.0	106.0	107.0
III.	103.5	103.2	105.5	106.5	106.2	105.0	105.2	105.0	105.0	105.0
IV.	102.0	102.5	104.0	104.5	105.0	105.0	104.5	105.0	105.0	105.5
	11	12	13	14	15	16	17	18	19	20
I.	106.5	105.8	105.6	105.5	106.2	106.2	106.0	105.5	105.8	105.5
II.	106.2	106.5	106.5	106.0	107.4	106.0	106.0	106.5	106.2	106.5
III.	105.8	105.0	105.2	106.2	106.5	106.0	106.5	106.0	106.2	106.0
IV.	105.0	105.2	105.6	106.0	105.5	105.2	105.0	105.0	104.8	105.0

Natural Temperature of Egg. — Since experiments show that

the above temperatures are too high for artificial incubation, it is necessary to push the inquiry a step further with a view of determining the exact temperature of the egg during natural incubation. The temperature of the hen recorded below was obtained from a thermometer attached to a block as described above. The temperature of the egg was taken in the following manner: A pail of lukewarm water was brought to a temperature of 98° F. (by the addition of warm or cold water). The egg was then placed in a tightly fitted rubber bag and held about four inches below the surface of the water. An opening was then made in the shell directly over the embryo, and a self registering thermometer warmed to 98° inserted for five minutes. The thermometer was inserted just far enough to bring its lower end at the center of the egg. As often as the eggs were broken for testing, they were replaced by eggs taken from other hens set at the same time.

	1	2	3	4	5	6	7	8	9	10
Hen.	102.2	103.0	103.5	104.0	103.8	105.0	104.6	104.5	105.0	105.0
Egg.	98.0	100.2	100.5	100.5	100.4	101.0	101.8	102.5	101.6	102.0
	11	12	13	14	15	16	17	18	19	20
Hen.	104.8	105.2	104.5	105.0	105.2	105.0	104.6	104.8	104.5	104.5
Egg.	101.8	102.2	102.0	102.5	102.0	103.0	102.4	103.0	103.0	103.0

A second series of readings was made by gently removing the hen from the nest and placing the thermometer in the groin for five minutes. The results are of course somewhat unsatisfactory since again the excitement of the fowls, due to their being removed from the nests, resulted in temperatures somewhat higher than normal.

	1	2	3	4	5	6	7	8	9	10
Hen.	103.0	105.0	104.8	104.2	105.2	105.0	104.8	104.8	105.0	105.0
Egg.	99.5	100.0	100.2	100.5	100.6	101.0	100.5	100.5	101.5	101.5
	11	12	13	14	15	16	17	18	19	20
Hen.	104.8	105.0	104.8	104.8	105.2	105.0	105.5	104.0	104.0	104.0
Egg.	101.5	101.2	100.8	101.8	102.0	101.8	102.2	102.0	102.4	102.4

While the above are the only sets of daily observations, they were supplemented by a number of scattered tests. In no case

was the egg found to exceed the temperature given in the table by more than one degree. In but few cases was it found to be a degree lower. Although it cannot positively be stated that these tested eggs would have hatched, the inference seems more than probable, since in five other cases where hens were set on eggs from the same flocks of fowls, the fertile eggs hatched with but very few exceptions. These observations show that the proper incubating temperature of the egg is about 100° for the first week; 101° for the second, and 102°–103° for the final week.

Temperature of Artificially Incubated Eggs. — The next problem is to determine what temperature must be kept in the air chamber of the incubator in order to obtain the above temperature of the egg. A series of observations was made on the artificially incubated egg. The temperature of the egg chamber was read from a thermometer placed flat and on a level with the top of the eggs, but not in contact with them. The temperatures of the eggs were taken in precisely the same manner as in the preceding experiment.

	1	2	3	4	5	6	7	8	9	10
Inc'b.	103.0	103.5	103.0	104.0	103.5	104.0	103.0	103.5	105.0	103.0
Egg.	100.2	100.0	100.0	101.2	101.6	101.8	101.6	100.0	102.8	101.0
	11	12	13	14	15	16	17	18	19	20
Inc'b.	103.0	104.0	105.0	103.0	104.5	103.0	105.0	104.5	106.0	106.0
Egg.	102.0	102.6	103.7	102.5	103.6	104.8	104.0	104.0	—	—

The above record was made from an incubator which hatched about 85 per cent. of the fertile eggs. The hatch, however, was somewhat premature, since many of the eggs hatched on the nineteenth day. It is thus evident that a temperature somewhat too high had been carried. In view of the irregularities of the incubator a second experiment was made.

	1	2	3	4	5	6	7	8	9	10
Inc'b.	102.0	102.0	103.0	102.0	102.5	103.0	102.5	102.0	103.0	103.5
Egg.	99.5	100.0	101.0	100.5	100.5	101.0	100.0	100.0	101.0	101.5
	11	12	13	14	15	16	17	18	19	20
Inc'b.	103.0	103.5	104.0	103.5	104.0	104.5	104.0	103.5	104.0	104.5
Egg.	101.5	101.8	102.0	102.5	103.0	103.0	103.0	102.5	102.5	103.5

As will be observed, the incubator was under better control in the second experiment and the chicks hatched on the twentieth and twenty-first days yet the percentage hatched was about the same as in the first, not including in either case the eggs destroyed in making the tests. While a more extended series of tests would be highly desirable, one certainly does not widely err in stating that the most favorable temperature within the egg chamber is close to 102°–103° F. the first half of the incubating period and 103°–104° F. for the latter half.

In any consideration of temperature, the fact must be kept in mind that as the chick grows, it gives off more and more heat, so that if an incubator of 200 egg capacity were entirely without artificial heating, the temperature would be much higher than that of the surrounding atmosphere; it consequently follows that less artificial heat is necessary during the later stages of incubation. The 102°–103° in the earlier stages is largely artificial heat, while the 103°–104° in the later stages would be the combined animal heat, given off by the egg, and the artificial heat supplied by the heat radiator.

V. Cooling of Eggs.

How frequently the eggs should be cooled and for how long a period, is a question of considerable importance. Not being entirely satisfied with the data at hand, an attempt was made to gather some information by actually watching a number of hens from day to day.

Natural Exposure. — Six hens were observed throughout the period of incubation and the results tabulated. It was found that the average time the hen leaves her nest, during the first fifteen or eighteen days is about thirty minutes. During the last few days of the incubating period she rarely leaves the nest. The longest time a nest was left exposed was an hour and twenty minutes, and the shortest time about twelve minutes. If the hen be obliged to forage for food, she remains a much longer time than when food is at hand. But one or two instances were noted in which the eggs were exposed for much more than an hour. It may be stated with a fair degree of certainty that the cooling of the eggs is due to the necessity of obtaining food, and in no way funda-

mentally affects the growth of the chick when there is an abundant supply of fresh air. There is not the least doubt, however, but what it has a beneficial influence in cases of poor ventilation, and since no incubator is supplied with too much, it probably is best to adopt the common practice of cooling the eggs. In so doing it would not seem advisable to cool the eggs for more than twenty to thirty minutes each day, for the first fifteen or eighteen days.

VI. Ventilation of Eggs.

Natural Ventilation. — In natural incubation a perfect ventilation exists. An abundance of fresh air can always reach the eggs by diffusing through the feathers which cover them. This process is constantly going on during incubation, the foul air likewise having free exit. There is thus ample opportunity for a continuous circulation of air, and there is every reason to believe that it takes place. There is also afforded by the feathers a complete barrier against sudden draughts of air. The fresh air is also raised to a certain temperature through the heat of the hen before it comes in contact with the eggs, which also serves to reduce any excessive humidity. This perfect system of ventilation cannot fail to impress one of its importance in facilitating the growth of the chick.

Dareste ('91, p. 150) conducted the following series of experiments: All the apertures of the incubator were closed during incubation, and upon examination it was found that nearly all the embryos had died. It was found further, that there had developed in the albumen a microscopic organism resembling the ordinary yeast plant. The author concludes that air modified by embryonic respiration, facilitates the growth of parasitic organisms.

Gerlach ('82, p. 115) found that by diminishing the quantity of air during incubation, he could cause dwarfing of the embryo. He then tried whether an increase in the size of the embryo could be brought about by increasing the quantity of air. A part of the shell was scraped very thin and placed in an incubator. During the first two days the normal and modified eggs were alike, but after that time the embryo in the scraped eggs developed at a remarkably rapid rate, nearly twice as fast as in normal growth.

A second method of increasing the supply of air was to remove whole pieces of the shell. Of course great care was taken not to injure the shell membrane or growing blastoderm. This fracture was made some distance from the embryo, so that the drying could not extend to the embryo, and the egg after the removal of the part of the shell was turned so that the broken portion was downward. The embryo was perfectly formed, but grew at the same astonishingly rapid rate.

The above consideration led to the conviction that artificial incubation can only proceed where there is an abundant supply of fresh air (oxygen). In order to confirm this supposition, the following experiment was tried.

Experiments. — Two incubators with similar ventilating systems, which, however, were believed to be inadequate, were employed. One was left with the ventilating system unmodified. The other was provided with two one-inch intake pipes. These extended to the outside of the building in which the incubators were located, and so arranged that a continuous current of fresh air passed into the egg-chamber.

Two egg trays of 100 capacity each, were filled with eggs from the same lots of fowls; special care being taken to divide the eggs from each flock so that there should be an equal number in each tray. The eggs were then subjected to exactly the same treatment, barring slight variations in temperature which necessarily existed.

On the fifth day the eggs were tested, and from the incubator with special ventilation, sixteen (infertile) eggs were removed. From the other, twelve (infertile) eggs were removed. On the twelfth day they were again examined. From the incubator with special ventilation seven dead embryos were removed and from the other, twenty. From the eighty-four in the incubator with special ventilation, seventy-two hatched, while five were dead in the shell, giving a percentage of 85.7 per cent. hatched from the fertile eggs. Of the eighty-eight eggs remaining in the other incubator, but thirty-nine hatched; a number of the remainder pipped, just how many was not recorded, while a large number were dead in the shell. There was thus hatched in the incubator without ventilation 44.3 per cent. of the fertile eggs.

But when a perfect ventilation has been obtained, it has produced certain deleterious effects which must be corrected. It is commonplace to say that when evaportion goes on in still air, this air soon becomes saturated, and evaporation, if not stopped, goes on very slowly. If, however, the saturated air is constantly removed and dry air takes its place, the rate of evaporation is increased. It is thus evident that any discussion of ventilation must take into consideration the question of moisture.

VII. Moisture of Eggs.

There is probably no one factor so little understood as that of moisture. The most careful observations of the nesting habits of the hen seem to only complicate the matter. A hen may build her nest on the ground, or in the hay loft, and in each case hatch about the same percentage. These facts, which are a matter of every-day observation, lead us to believe that eggs hatch equally well under these variable conditions. The moisture necessary for development must then be controlled by the hen, or egg, or both.

There are certain constant factors in the production of moisture which we may accept as existing. First of all, the temperature of the air in the nest is far higher than that of the outside air. As the two come in contact, there is more or less moisture produced. A second source is from the perspiration of the skin. A third source is from the egg itself. These three sources supply, so far as we are able to determine, the moisture necessary for the normal development of the egg.

It is known through the experiment of Reaumer, that excessive moisture gives rise to the pathological forms. Dareste (p. 159) also records an experiment in which the atmosphere was saturated and as a result the albumen liquified and leaked through the shell. Furthermore, Dareste, stated that excessive moisture facilitates the growth of parasitic forms which develop in the albumen.

The writer made a series of daily hygrometer tests with a view of ascertaining just how much moisture existed in the nests. In testing with the hygrometer, it was placed in the nest among the eggs, and at the end of fifteen minutes was taken out

and the reading recorded. Although a great number of these tests were made and tabulated they were later discarded, owing to wide variations in the hygrometers and the problem attacked in another way. It is of course well known that the egg decreases in weight during incubation and that this is due chiefly to the evaporation. In order to find out definitely how much evaporation goes on during natural incubation, thirty-six eggs were weighed each day for twenty days and these weighings tabulated. It was found on the average that the egg during natural incubation loses about 13 per cent. of its original weight.

It was also found by experiment that the evaporation could be lessened until the egg lost but 9 per cent of its original weight and still give a healthy chick. It was likewise learned that evaporation could be increased up to about 20 per cent and the eggs give rise to perfect chicks. It would thus appear that the moisture in the incubator should be so controlled that it will allow the evaporation of about 13 per cent of the original weight of the egg.

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'91 Production artificielle des monstruosities. Paris, 1891.

Gerlach, M.

'82 Doppelmisbildungen bei den höheren Wirbelthieren. 1882.

Reamur.

'49 Art de faire éclore d'eleve en toute saison des oiseaux domestique de toutes espèces, soit par le moyen de la chaleur des furnier, soit par le moyen de celle du feu ordinaire. Paris, 1849.